Permutation Test for Autocorrelation in Annual Mean Temperature

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Introduction

Autocorrelation in climate time series is often present because measurements from consecutive years are not independent. As a result, the usual p-value associated with a Pearson correlation coefficient is not appropriate. To evaluate whether annual mean temperatures in Key West exhibit significant correlation between successive years, a permutation-based test was applied. This approach constructs an empirical null distribution that does not rely on the assumption of temporal independence.

Methods

The correlation between temperatures in year t and year $t + 1$ was first calculated using the original ordering of the annual mean temperature series. This statistic served as the observed value.

To generate the null distribution, the temperature series was randomly permuted 10,000 times. For each permuted sequence, the correlation between adjacent positions was recalculated. Because the order of years is destroyed in each permutation, these values approximate the correlations expected when no temporal dependence is present.

A one-sided permutation p-value was obtained as the fraction of permuted correlation coefficients that were greater than or equal to the observed value.

Results

The distribution generated by the permutations is centred near zero, as expected under the null hypothesis of no autocorrelation. The observed correlation lies on the right tail of this distribution, indicating that it is rarely produced by random permutations of the data. The resulting one-sided p-value is small, showing that consecutive years exhibit a statistically meaningful positive relationship.

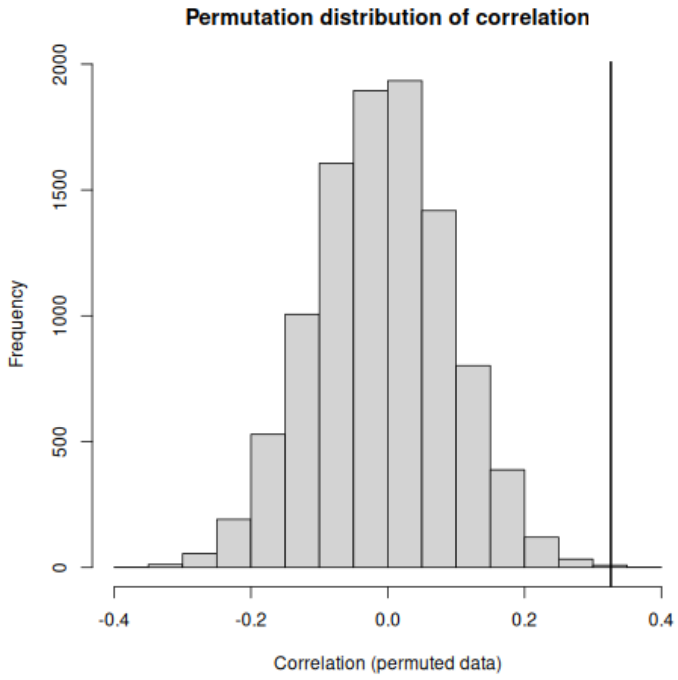

Figure 1: Permutation distribution of adjacent-year correlation coefficients. The vertical line marks the observed correlation calculated from the original temperature series.